DESIGN AND EVALUATION OF A TOWED AC MAGNETIC SOURCE VEHICLE

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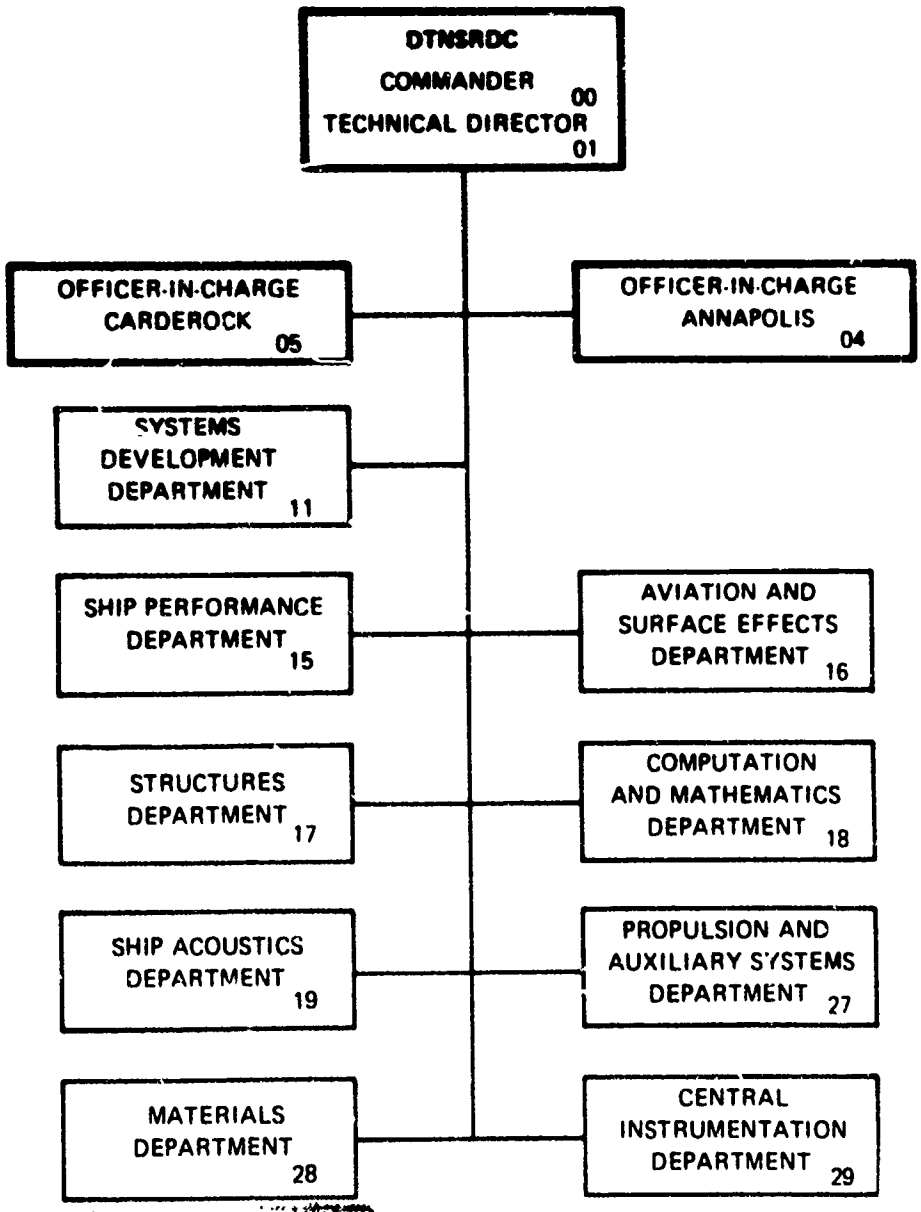

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An economical towed vehicle to provide a sta' e platform for an AC magnetic source at a speed of 4 knots and depth of 300 feet is designed and evaluated in at-sea experiments. The vehicle towed satisfactorily over the designed speed range and achieved the design objective.

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INTRODUCTION

At the request of the Johns Hopkins University Applied Physics Laboratory (JHU/APL), the Naval Ship Research and Development Center (NSRDC) undertook a program to design and develop the towed vehicle system for Project Classic Thicket. In the course of this program, a requirement was identified to design an additional towed vehicle to provide an AC magnetic source for Classic Thicket experiments.

This report states the performance requirements for the vehicle and presents the rationale for the various factors in its design. It describes the vehicle and presents selected results from at-sea evaluations.

DESIGN CONSIDERATIONS

The initial performance requirements for the vehicle may be stated as follows:

1. The vehicle was required to provide a reasonably steady platform for a large orthogonal pair of electrical coils. These were of rectangular form, approximately 3 feet by 4 feet in size, and were to be located in the horizontal and in the longitudinal vertical planes of the vehicle.

2. The vehicle was required to attain a towing depth of 300 feet at a speed of 4 knots. Also, it was desirable to limit depth changes

with speed at that design point. The towcable was specified by APL to be of double-armored type, 0.464 inch in diameter, and having an estimated weight in water of 0.7 pound/foot. Approximately 800 feet of total towline length was available.

3. The vehicle was required to be lightweight and compact enough to permit launching and recovery by means of a radial-arm davit on R/V COVE, the vessel designated for the experiments.

Based on these considerations, the design for a lightweight winged vehicle developing a total downforce at 4 knots of 445 pounds was prepared. The general configuration of the vehicle included a boom-type fuselage, large cruciform tails aft, a wing and towpoint located just ahead of the tails, and a ballast weight at the nose to maintain the vehicle near level in static pitch. The total weight was estimated to be approximately 135 pounds, so the wing was designed to produce approximately 310 pounds of lift at 4 knots.

The basic geometrical configuration selected for the vehicle is shown by sketch in Figure 1 and the assembled vehicle is shown in Figure 2. Principal physical characteristics of the vehicle are presented in Table 1.

TAIL GEOMETRY

The electrical coils were paneled over with glass-reinforced plastic (GRP) sheet and used to provide large vertical and horizontal stabilizing tail surfaces in a cruciform configuration. The resulting surfaces had flat-plate sections with thicknesses of approximately 1 inch.

WING GEOMETRY

Wing geometrical parameters were scaled from an existing lifting device of simplified construction which had been designed by NSRDC for airborne

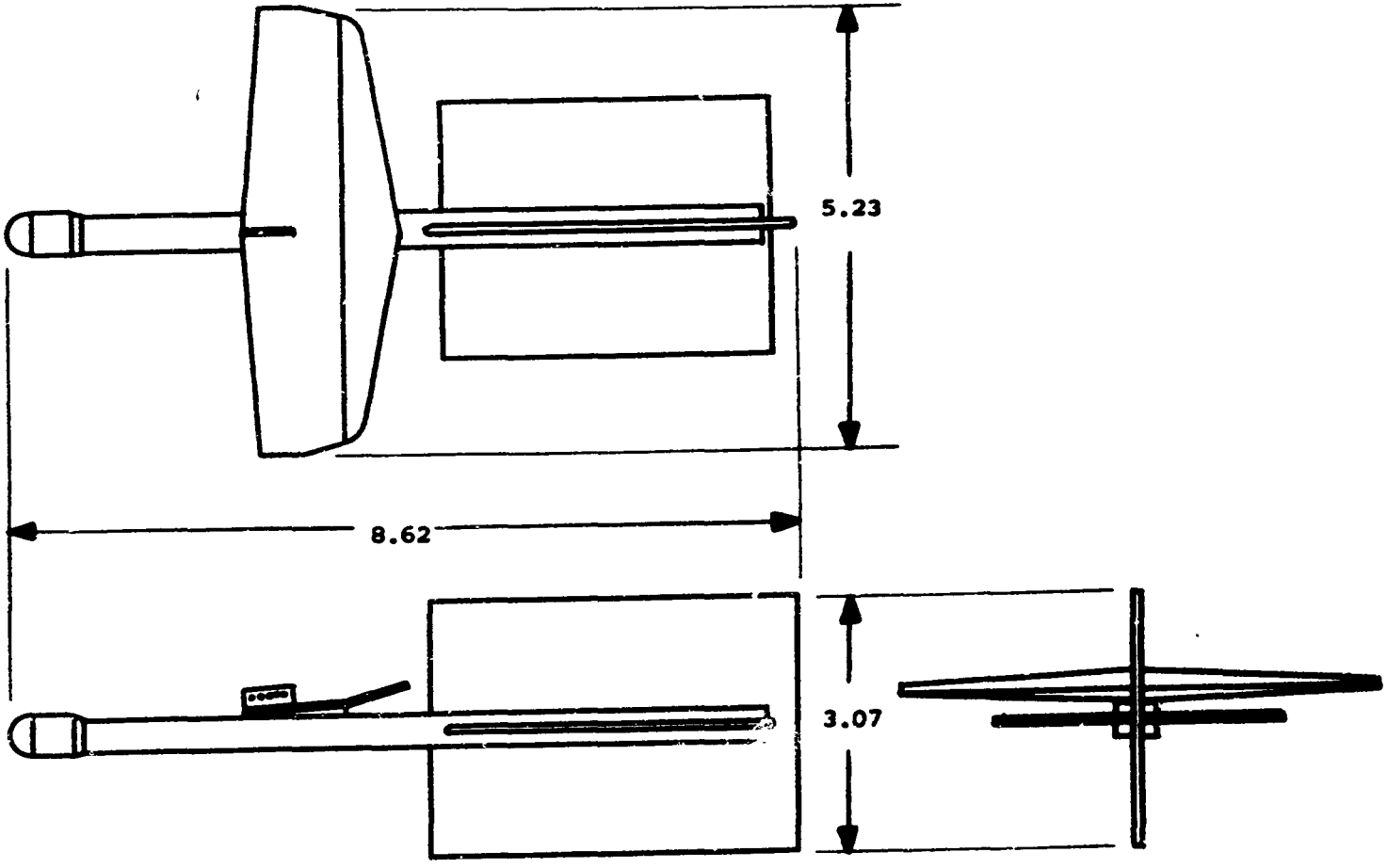
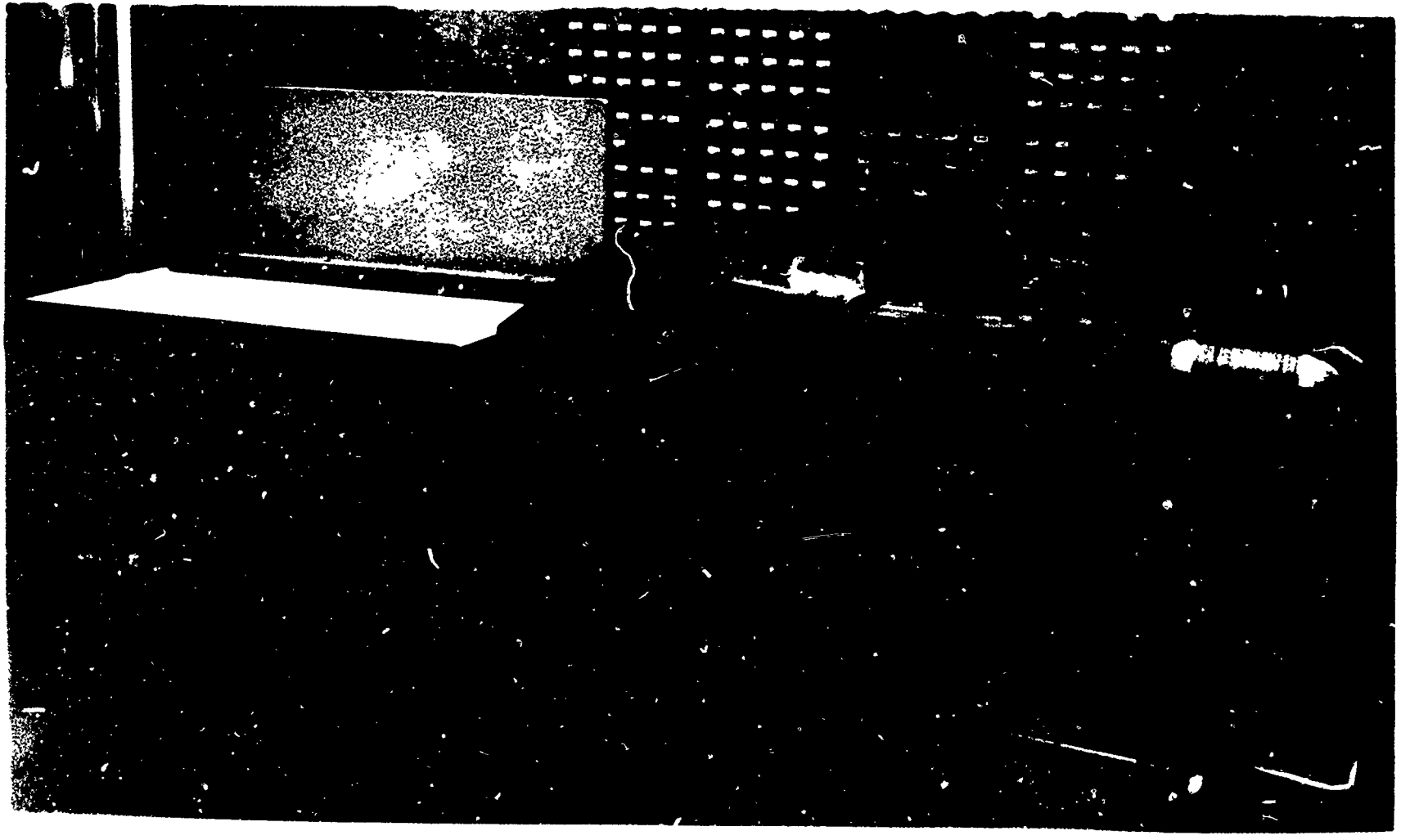


Figure 1 - Towed AC Magnetic Source Vehicle



APL Photo

Figure 2 - Towed AC Magnetic Source Vehicle

TABLE 1 - PRINCIPAL PHYSICAL CHARACTERISTICS OF THE TOWED AC MAGNETIC SOURCE VEHICLE

Overall	
Length, feet	8.62
Beam, feet	5.23
Height, feet	3.07
Weight in seawater, pounds	135
Fuselage	
Construction	Wood
Length, feet	7.45
Width, feet	0.41
Height, feet	0.41
Wing	
Construction	Aluminum alloy plate
Section	Flat plate with round leading edge, square trailing edge, and 29 percent (mean) trailing-edge bent flap
Span, feet	5.23
Root chord, feet	1.99
Tip chord, feet	1.07
Taper ratio	0.54
Area, square feet	7.85
Aspect ratio	3.48
Flap bend angle, degrees (trailing edge up positive)	13.5
Angle of incidence of main wing flat with respect to fuselage, degrees (leading edge up positive)	-4.0
Vertical Stabilizer	
Material	GRP panels sandwiched over foam core
Section	Flat plate with round leading and trailing edges
Span, feet	3.07
Chord, feet	4.07
Area, square feet	12.50
Aspect ratio	0.75
Thickness, inches	1.0

TABLE 1 - PRINCIPAL PHYSICAL CHARACTERISTICS OF THE TOWED AC MAGNETIC SOURCE VEHICLE (CONT'D)

Horizontal Stabilizer	
Material	GRP panels sandwiched over foam core
Section	Flat plate with round leading and trailing edges
Span, feet	3.07
Chord, feet	3.59
Area, square feet	11.02
Aspect ratio	0.86
Thickness, inches	1.0
Angle of incidence, degrees	0

minesweeping applications. Since ample hydrodynamic data had been obtained for this existing device, the wing could be accurately sized to provide the necessary forces without requiring a lengthy design process.

Wing planform dimensions and towpoint locations were scaled linearly from the existing device by a ratio of approximately $\sqrt{2}$:1. Several alternative towpoints also were provided. Wing thickness was preserved since the AC vehicle has a lower design speed range than the minesweeping device. Wing flap bend angle also was preserved.

AT-SEA EVALUATION

The vehicle was towed initially from R/V COVE in the Florida Straits using a double-armored steel towline 0.464 inches in diameter. Towline lengths of 25 and 600 feet were employed, and the vehicle towing depth was measured with an estimated accuracy of $\pm$10 feet by means of a pressure transducer mounted on the fuselage.

On 25 feet of towline, the vehicle was observed to tow in a steady manner. After the kite angle had been trimmed by means of small sheet-metal tabs on the wing trailing edges, a total towline length of 600 feet was paid out. At a speed of 3.9 knots, a towing depth of 310 feet was achieved.

CONCLUSIONS

Based on the at-sea evaluations, the following conclusions may be drawn:

1. The vehicle tows in a dynamically stable and steady manner over the desired speed range, and

2. The vehicle satisfies the depth-speed requirement.